AD-A082 343 MCDONNELL DOUGLAS ASTRONAUTICS CO-ST LOUIS MO F/G 5/9
LOW-COST TERMINAL ALTERNATIVE FOR LEARNING CENTER MANAGERS.(U)
FEB 80 C J NIX, T TATE, S C DUTKA F33615-78-C-0037
UNCLASSIFIED AFHRL-TR-79-77 NL

END
DATE
FILMED
4 80
DTIC

AFHRL-TR-79-77

LEVEL II

AIR FORCE HUMAN RESOURCES LABORATORY

ADA082343

LOW-COST TERMINAL ALTERNATIVE FOR LEARNING CENTER MANAGERS

By

C. Jerome Nix
Thompson Tate
Stephen C. Dutka
Harold L. Montgomery
David P. Showers
Thomas G. Klem
McDonnell Douglas Astronautics Company—St. Louis
P.O. Box 516
St. Louis, Missouri 63166

Alan P. Marshall

TECHNICAL TRAINING DIVISION
Lowry Air Force Base, Colorado 80230

February 1980

Final Report

Approved for public release; distribution unlimited.

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

NOTICE

This final report was submitted by McDonnell Douglas Astronautics Company St. Louis, P.O. Box 516, St. Louis, Missouri 63166 under contract F33615-78-C-0037, project 1121, with Technical Training Division, Air Force Human Resources Laboratory (AFSC), Lowry Air Force Base, Colorado 80230. Mr. Alan Marshall (TTO) was the Contract Monitor for the Laboratory.

This technical report has been reviewed and is approved for publication.

MARTY R. ROCKWAY, Technical Director
Technical Training Division

RONALD W. TERRY, Colonel, USAF
Commander

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFHRL-TR-79-77	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) LOW-COST TECHNICAL ALTERNATIVE FOR LEARNING CENTER MANAGERS		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) C. Jerome Nix, Harold L. Montgomery, Alan P. Marshall, Thompson Tate, David P. Showers, Stephen C. Dutka, Thomas G. Klem		8. CONTRACT OR GRANT NUMBER(s) F33615-78-C-0037
9. PERFORMING ORGANIZATION NAME AND ADDRESS McDonnell Douglas Astronautics Company St. Louis, P.O. Box 516, St. Louis, Missouri 63166		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62205F 11210229
11. CONTROLLING OFFICE NAME AND ADDRESS HQ Air Force Human Resources Laboratory (AFSC) Brooks Air Force Base, Texas 78235		12. REPORT DATE February 1980
		13. NUMBER OF PAGES 24
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Technical Training Division, Air Force Human Resources Laboratory, Lowry Air Force Base, Colorado 80230		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer-Assisted Instruction (CAI)
Computer-Managed Instruction (CMI)
Technical Training (TT)
Advanced Instructional System (AIS)
training devices
Computer-Based Training (CBT)
Computer-Based Instruction (CBI)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This study established the feasibility of replacing high performance and relatively expensive terminals with less expensive ones adequate for supporting specific tasks of Advanced Instructional System (AIS) at Lowry AFB, Colorado. Surveys of user requirements and available devices were conducted and the results used in a system analysis. The results of the analysis formed the basis for determining the detailed hardware requirements and subsequent hardware selection, procurement and installation. Additionally, the software modifications necessary to accommodate the new hardware were made and the resultant total system was evaluated in an operational training environment.

SUMMARY

PROBLEM

The prototype Advanced Instructional System (AIS) at Lowry AFB utilizes a plasma panel terminal for all interactive applications in computer-based training. These applications range from Computer-Aided Instruction (CAI), utilizing the graphic capabilities of the terminal, to simple Input-Output operations, such as operational data base changes and data extractions which are part of Computer-Managed Instruction (CMI). Examination suggested that the rather extensive capabilities of these terminals were not being fully exploited on many applications. In addition, recent years have seen a steady decrease in terminal costs such that a less-expensive terminal could be feasible for the more basic applications. A study was therefore devised to determine the feasibility of operating standard, inexpensive terminals in parallel with existing terminals and eventually replacing these comparatively expensive terminals with inexpensive ones as additional needs developed.

APPROACH

The Weapon Mechanics (WM) Course was the AIS area of instruction having the most operational terminals and was chosen as the test bed for introduction of low cost terminals. The associated project was organized in three phases. Phase I objectives were to establish feasibility, identify terminal requirements, and determine necessary communication needs. Phase II included system design, software/hardware changes, and procurement of equipment. Phase III was for integrating the system, installing the hardware, and evaluating the final product.

RESULTS

Low-cost terminals at approximately $1200 each were identified and purchased. These low-cost terminals were installed and the required software changes made. Operation of the low-cost terminals has proved their cost effectiveness for use in a computer-based system such as the AIS. As the system is expanded, the apparatus now exists to expand with whatever terminal, or mix of terminals, most effectively meets the needs and budget.

The use of a standard terminal in parallel with the non-standard one originally specified for the AIS has proved to be both cost effective and desirable. The diverse needs of the various applications in a complete CMI/CAI system can best be satisfied by a "mix" of terminal types, and such a "mix" should be considered in any future expansions of the AIS.

TABLE OF CONTENTS

1.0 INTRODUCTION

The Advanced Instructional System (AIS) plasma-panel terminal at Lowry AFB, while being a very effective instructional tool, remains a relatively expensive device. Many instructional system applications do not require graphics or special keyboards. Thus, lower cost terminals could be used. It was determined, therefore, that a more cost-effective device should be sought. A review of industry communications standards and an evaluation of features available on state-of-the-art terminals was required to recommend replacement equipment. This industry review could then be correlated with classroom functional requirements and program frequency of use so that a set of characteristics could be identified as requirements for the target terminals. Also, the feasibility of using such terminals in parallel with the current device and possibly with a mix of terminals was to be determined. Certain software programs would have to be changed and hardware modifications made. After these changes/modifications were complete, the equipment could be installed in the classroom and evaluated.

2.0 STUDY PLAN

The study plan divided the project into three phases. These included a trade study and hardware selection period, a specification and preliminary development period, and a final checkout and evaluation period.

The initial time frame, Phase I, included four independent surveys. A user-needs trade study considered programs, special keys, and displays required by learning center managers. A communications trade study examined hardware suitable for connecting to the host Cyber 7316 computer and the availability of modems and multiplexers. Another trade study surveyed the available low-cost alphanumeric terminals and considered pertinent characteristics. A software analysis considered the impact on the existing AIS operating system and application programs. At the end of the initial phase, terminals, communications front-end hardware, and modems were selected for procurement. Also, software which would have to be modified or augmented was identified.

During Phase II of the project, pertinent characteristics of the selected network processing system, modems, and terminals were categorized. Then, keyboard mappings were designed, operating system configuration requirements were considered, and language and application program changes were detailed. Coding and preliminary checkout of application programs began during this time period, and the new terminals and modems were procured.

The final phase of the project was the installation and validation phase. As the initial actions in this phase, software and hardware changes were completed. A subsequent checkout of the design and final installation of the terminals in the classrooms were then completed. Validation of the entire system by test and evaluation of terminals by users in the classrooms completed the final phase.

3.0 PHASE I, SURVEY AND TRADE STUDIES

The four Phase I trade studies began simultaneously. The studies were made with the goal of using standard communications systems and protocol whenever possible. The aim was to find a terminal which could handle full duplex (two-way simultaneous) transmission of data; the American Standard Code for Information Interchange (ASCII) 96-character set consisting of numeric, punctuation, and uppercase and lowercase alphabetic characters; and a rate of 120 or more characters per second on a screen of about 25 lines with 64 to 80 characters per line.

The four trade studies had the following individual objectives:

1. Determine user needs by considering the frequency of program execution and the terminal functions used most by these programs.

2. Identify a low-cost alphanumeric terminal which possesses the required attributes and which is reasonably priced.

3. Identify communication processing equipment which can be connected to the AIS Cyber computer to operate four terminals, and determine the types of modems which would be most cost effective for transmitting data within the Lowry AFB environment.

4. Ascertain the required software modifications.

3.1 USER NEEDS SURVEY

The first of the User Needs Survey exercises was an examination of the tasks performed by AIS instructors, learning center managers, and students. Once the tasks were defined and the frequency of performance assessed, the related programs used were noted, and those used the most were identified for eventual conversion to the low-cost terminal. The programs which were referenced the most were monitored to determine usage of the special meaning keys. The resultant keypress data were then used in the selection of a terminal and in the later Phase II and Phase III development of software modifications.

Programs used the most included:

1. FORMS - Simulation of forms alternatively read in from an AIS management terminal.

2. RESAV - Information on resources available in learning centers.

3. SDP - Student data profile information.

4. PSCRS - Displays of a student's preassessment scores.

5. CHGED - Used to display proposed changes and their status.

6. CAI - The student's computer-aided instruction presentation program.

It was found that all of these programs could make use of a standard typewriter-like keyboard with the addition of several special function keys, similar to those used on the AIS terminals. Keys to be considered for addition included -Next-, -Back-, -Term-, as well as other function keys. For display purposes, it was found that lines would be useful, and that for some programs an "all-dots-on" character could be used for limited graphics. None of the programs referenced used any detailed graphics or required a vector or dot line generating mode.

As a result of this survey, programs used frequently were noted for possible modification. A second result of this survey was establishment of a need for function keys. A third result was determination that many of the programs noted used the same set of subroutines; in many cases, only a change of the common subroutine library and individual editor pages from a 32-line format to a 24-line format would be required.

3.2 COMMUNICATION TRADE STUDY

The goal of the Communication Trade Study was to (a) identify the common communication characteristics used throughout industry which should be used in the low-cost terminal, (b) identify a front end processor which could be connected to the AIS Cyber computer for operation of the four terminals, and (c) identify hardware such as modems and multiplexers which would be necessary to interface the terminals in the classrooms with the computer.

The current AIS communication system was reviewed and a set of target characteristics defined so as to allow the use of standard equipment while maintaining a degree of compatibility with the AIS operating system software. The targeted characteristics included:

1. Provisions for full duplex two-way communication using two pairs of telephone wires for each terminal.

2. Character-at-a-time transmission such that every keypress sent from the terminal can be sent to the central computer, optionally timed and/or converted to another character under program control, and then returned to the terminal for display.

3. A standard ASCII set of 96 characters, and the capability of sending up to eight data bits on each transmission.

4. A data rate which permits transferring 120 or more characters per second from the central computer.

In addition to these target characteristics, it was necessary that the communication hardware be able to handle at least four terminals, be easily expandable, be relatively inexpensive, and be available soon after receipt of an order.

3.2.1 Communications Front Ends. After reviewing the various available communications processors which could be interfaced with Control Data Corporation (CDC) machines and which were in the correct price range, three units emerged as acceptable. The CDC 2551 Network Processing Unit (NPU) was selected as the best approach, primarily because a leasing arrangement was available, and it has been operating since March 1979.

3.2.2 Modems and Multiplexers. To support transmission of data on telephone lines between the communications processor and the terminals, two systems of trunk line modems and multiplexers were studied for use with the original four terminals. Studies of the first system considered the attributes of trunk line modems from five different manufacturers. These modems are for use at each end of a voice grade telephone line between buildings. Of the five considered, the Timeplex 202 was selected as the best for this application. A second system, consisting of a pair of statistical multiplexers and short-haul, higher-speed modems, was also evaluated. As a result of this evaluation, it was determined that this multiplexer system was best if eight terminals, or more, were to be used. Next, a cost comparison of the two systems was made, and it was determined that the most cost-effective system for less than eight terminals was the modem pairs. Since the subject contract stipulated installation of only four terminals, the Timeplex 202 system was procured and installed using the 2551 NPU and the selected terminals.

3.3 TERMINAL TRADE STUDY

One of the primary goals for this project was identification of one or more terminals which could be used by learning center managers and students to satisfy non-graphics requirements, such as selected editors and CAI programs. The terminal requirements were partially identified by first considering the current AIS terminal attributes. A subset of these characteristics which was considered necessary to effective performance of the current mission was also used as a factor in developing a list of candidate terminals. The final terminal for learning center manager and student use was then selected from this list.

The most pertinent AIS terminal characteristics include:

1. A display capable of presenting 32 lines of 64 characters per line with up to 126 built-in characters plus 126 user-designed characters, and a graphics capability of 512 by 512 dots.

2. Terminal electronics capable of erasing the screen and positioning the cursor or next writing position to any location on the screen.

3. A keyboard that uses the standard typewriter QWERTY layout with a numeric pad, special function keys, and three shift keys.

4. A terminal that requires a non-standard protocol which presents 19 data bits to the terminal every 16.6 milliseconds and sends back 10 data bits to the host computer. Special format electronics are required which cannot be used with standard RS232 equipment.

After reviewing the AIS terminal characteristics, a study was made that included approximately 300 commercially available terminals. Using the results of this study and the current AIS program requirements, the following target attributes were identified:

1. The display should present 24 or 25 lines of up to 80 characters per line. The character set should contain at least the 96 standard uppercase and lowercase alphabetic characters, numbers, and punctuation and should have lowercase descenders for easy readability. The ability to erase the screen and to preset the cursor to any character position is also desired.

2. The keyboard should have a standard typewriter keyboard in the QWERTY sequence, should have a limited number of function keys or a way of simulating a non-displayable sequence, and should not require a numeric pad.

3. The terminal should support full duplex character-at-a-time transmission, while operating at 120 characters per second or faster.

4. The terminal price should not exceed $1,500.

After identifying the required attributes, the number of candidate terminals was reduced from about 300 to 5 terminals. These five terminals were evaluated individually through demonstration by manufacturing representatives, and one was deleted from the list of candidates because of poor picture quality. The Phase I trade study concluded with a recommendation for a side-by-side comparison of the remaining four terminals for a final evaluation. This was accomplished as part of Phase II.

3.4 SOFTWARE ANALYSIS

A software analysis was made in parallel with the other trade studies to determine the impact of changing terminal format and of communicating via a new network processing system. The analysis indicated the following:

1. Screens displaying data for programs to be changed would have to conform to the format of the new terminal. This would mean converting the 32 line by 64 characters per line display of AIS terminal programs to 24 lines with, most probably, 64 characters per line.

2. A Computer Assisted/Managed Instructional Language (CAMIL) "direct drive" primitive would have to be prepared which would permit sending seven- or eight-bit data direct to the terminal for control and screen positioning.

3. The editor executive routines and accept procedures would have to be modified and the editor pages which exceeded 24 lines would have to be restructured.

4. The CAMIL sentence facility would require code changes for applications programs.

5. ASCII lookup tables would have to be provided in the driver part of the operating system to convert the CAMIL format characters to standard terminal values.

The analysis also indicated that the operating system might have to provide new input and output peripheral processor programs to drive the CDC 2551 NPU. A package leased from CDC would operate the firmware used in the CDC 2551 hardware, so no modification or design of firmware would be required for the NPU itself.

3.5 CONCLUSION

At the end of Phase I, it had been determined that a low-cost terminal system, operating in parallel with the current terminal system, was feasible. More specifically, it was decided that a parallel system for standard terminals was more cost effective and expandable than interfacing the low-cost terminal with the current communication system. Also, software studies predicted success for use of the chosen NPU and communication modems. Procurement of the modems and the NPU began during this phase, and the candidate terminals were reduced to four.

4.0 PHASE II - DESIGN AND DEVELOPMENT

Phase II began with the selection of the Applied Digital Data System (ADDS) Regent 100 terminal as the low-cost terminal for the system. This was a result of the side-by-side demonstration and evaluation recommended at the conclusion of Phase I.

The main efforts during Phase II were a study of the hardware and software details and design into the current system of the changes necessary to implement the new system.

4.1 HARDWARE

Pertinent hardware characteristics of the NPU, the 202C modems, and the ADDS Regent 100 terminals were examined to determine the necessary interfaces and software requirements.

4.1.1 Network Processing Unit. The hardware module configuration of the CDC network processing system was evaluated during Phase II. The hardware consists of a network processor with 32,768 16-bit words of memory, a channel coupler to the CDC Cyber 7316 computer, two communication line adapters (CLAs) - each of which handle two terminals using RS-232-C electronic interfaces - and a console terminal for configuring the system and for providing diagnostic information. The system as leased will handle up to 16 terminals with the addition of communication line adapters, and up to 32 terminals by adding extra memory and extra CLAs.

4.1.2 Timeplex 202C Modems. Optional electrical connections of the modems between the terminals and the central site were considered. Since the terminals could be placed some distance from each other, separately packaged modems were specified for operation at the terminal locations. Each separate package has its own power supply. For the central site, one package with one power supply and four modem cards was specified. The central site is expandable to handle up to 14 modem cards.

Various methods of looping back data to be used for diagnostic checkout of the modems were also considered. Both analog and digital loopback methods are available on the Timeplex modems.

4.1.3 ADDS Regent 100 Terminals. Operational details of the terminal were evaluated from a programmer's point of view. Included were the switch settings, display characteristics, control and attribute tables, and the keyboard.

1. Included in the switch settings for terminal control were (a) full duplex, even parity modes, (b) 1200 bits-per-second, (c) a CR(15_8) line terminator with automatic line feed, and (d) auto scroll off.

2. The display consists of 24 lines of 80 characters, with a 25th line of status information. The terminal provides the standard 96 ASCII characters of uppercase and lowercase alphabetic characters, numbers, and punctuation. Also included are 11 box drawing symbols along with an additional 32 symbols corresponding to control codes.

3. Tables were designed which explained how to manage the ADDS terminal under control of the host computer. Tables include (a) visual attribute control, such as normal white on black, reverse video, half intensity, and underline, (b) line drawing symbol generation codes for boxes, (c) ASCII input and output, and (d) control codes for clearing the screen, line spacing, and other standard control procedures such as setting the cursor.

4.2 SOFTWARE

During Phase II, the AIS software to be modified or added in support of the low-cost terminal was designed on the basis of the expected operation of the new equipment. Software was planned in the areas of expected keyboard mapping from the current AIS terminal to the ADDS Regent 100 keyboard, expected parameters required for the communications software, CAMIL language changes needed to support the new features, and applications programs earmarked for modification. Software considerations are briefly reviewed in the following paragraphs.

4.2.1 Keyboard Mapping. Since the ADDS terminal standard keyboard has fewer keys than the AIS terminal keyboard and has only 16 available numbered function keys versus the AIS terminal's 24, a preliminary mapping was laid out for correlation between the two terminals. Special symbol and special meaning keys were also considered.

4.2.2 Communication System Considerations. Changes and possible additions to the operating system driver were considered in terms of functions needed, such as erasing a screen or moving the cursor to the next line. Various alternate routines were examined for the best location to place the 12-bit CAMIL code to 7-bit ASCII code conversion tables and related logic. During Phase II, the three best areas for providing the conversion appeared to be the CDC 2551 communications processor, the DRIVER peripheral processor program, and the Cyber central processor. Also, modifications that might be necessary for other ASCII terminals were considered.

4.2.3 CAMIL. It was decided that the CAMIL language would need several new features to support the ADDS terminals. After modification, CAMIL would (a) ignore ADDS terminal inputs when no mapping was provided for a key which had no meaning in the current system, (b) make available to the application program information about the type of terminal connected, (c) provide a transparent mode-setting

procedure so that the terminal could be operated in the underline or other modes, and (d) provide a direct binary output procedure to send octal commands to ADDS or other ASCII terminals to handle non-supported functions.

4.2.4 Application Programs. A number of programs were selected for possible conversion and operation on the new terminals, with most of the programs being data base editors. The editor executor subroutine should be modified to handle the new attributes, to accept lines changed from lines 28 through 32 to lines 20 through 24, and to provide double spacing at a different number of lines than is used on the AIS terminals. It was determined that editor pages would be modified, when necessary, to handle the lower number of lines on the new terminals, and array pages would be changed so that only data fields would be rewritten when a field was changed. Also considered was the fact that CAI formats would be changed, when necessary, so that data taking more than 24 lines would be efficiently displayed. To make the programs more readable, increased use of the CAMIL sentence facility would be considered during all program modifications.

4.3 CONCLUSIONS

System design was completed during Phase II. The feasibility of the low-cost terminal system was established and the equipment chosen and procured. Base communications circuits necessary for connecting the terminals were also implemented during Phase II. Finally, the application programs requiring change were identified and several of the modifications accomplished.

5.0 PHASE III - INSTALLATION AND VALIDATION

During Phase III, the operating system was modified to handle the new CDC 2551 hardware, the CAMIL primitives and terminal control and identification commands were completed, and selected application programs were modified for the new ADDS terminals. Refinement and final testing of the various system, language, and application programs for incorporation into the AIS were also accomplished during this phase.

Additionally, the network processor, along with the terminals and the modems, were received during this period. This hardware was subjected to individual and system tests prior to final installation. Although the original specifications called for installation of the terminal hardware in the Weapons Mechanic (WM) Course, a decision was made during this phase to utilize the Precision Measuring Equipment (PME) Course for the test installation.

5.1 HARDWARE

The sequence of events for the hardware portion of Phase III was (a) delivery and installation of the NPU, (b) delivery of modems and terminals, (c) system testing of all the hardware with the newly developed software, (d) final installation of terminals in the classrooms, and (e) evaluation of the entire system.

5.1.1 Network Processing Unit

Cost considerations associated with buying or leasing software for the CDC 2551 Communication Processor led to the purchase of the 2550-101 6671 emulator as the most efficient way to drive a small number of standard terminals. Because this emulator package will drive up to 16 terminals in a full duplex mode it was considered more than adequate for driving the four low-cost terminals. If, however, a future decision is made to expand to a large number of standard terminals or to totally convert to a standard communication system, a different approach should be considered. For example, the current character rate is approximately 10,000 characters/second, and given the standard AIS character rate of 120 characters/second, a limitation of 126 terminals would result.

5.1.2 Network

The network used with the low-cost terminal system is characterized by inherent standardization. The system operates at 1200 bits per second using an ASCII character structure (bit sequence) in a full-duplex, asynchronous mode. The interface of the digital port of the modem conforms to Electronic Industries Association Standard RS-232-C, Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange, August 1969.

The data circuits to support the low-cost terminals for the PME Course consist of dedicated voice grade lines between the AFHRL and the PME Course building at Lowry AFB. The data communication for each terminal includes a rack mounted Timeplex 202 modem card at the central site, the dedicated telephone wire data circuit, and a desktop Timeplex 202 modem at the terminal.

During the interim period between equipment testing and final installation, one of the low-cost terminals was located in the Lowry AFB Headquarters building with a data circuit established between it and the AFHRL building, a line length of over 4000 feet. Experiments were conducted to transfer data between the terminal and the network processing unit without modems which required some configuration modifications, e.g., special cable strapping. In this configuration, the terminals operated at 1200 bits per second (bps) with no reported errors in transmission. When the operating speed was increased to 2400 bps, however, occasional parity errors occurred. Above 2400 bps, communication over long distances was not possible without modems. Within 50 feet of the NPU, however, terminals were operated at 9600 bps with no noticeable errors. It was, therefore, concluded that because of required classroom reliability, the PME terminals should not be operated without modems at speeds above 1200 bps. A further result of the test was the decision that because of the short distances involved, data circuit requirements within the AFHRL building could consist of four-wire dedicated lines for each terminal with no modems required.

5.1.3 Terminal Evaluation

The low-cost terminals were installed in the PME Course building for daily operational use by instructors and learning center managers who were asked to evaluate the utility of the terminals in a training environment. Features of the terminals most admired were appearance, operation, size, and keyboard layout. The only negative feature was the somewhat distracting characteristic of the terminal's flashing cursor. Other details of the evaluation are given below.

5.1.3.1 Problems. When the terminals were first installed in the learning centers, some problems were noticed when logging on the system. The problem was associated with attempting to change from uppercase to lowercase while the log-on program was operating and a user was typing in his/her identification and password. The problem has since been resolved.

An on-going operational problem is related to attempts by users to access unmodified plasma terminal programs. These programs, such as the hierarchy editor, have not been modified for the format of 24 lines and the "text only" availability of the new terminals. These programs, and others yet to be identified, may need to be modified if user requirements warrant.

The only terminal hardware malfunctions that occurred during the entire contract period were two terminal power-supply failures. This could be a pattern failure and will be carefully monitored.

5.1.3.2 Conclusion. The results of Phase III validated the terminal display format, keyboard layout, and communications characteristics requirements established during Phase I. Additionally, user acceptance of the ADDS Regent 100 terminals with the related software and hardware system was very favorable.

The project goals of identifying required characteristics of terminals and of demonstrating their validity were achieved. An added benefit was the high degree of preference and acceptance of the system by the classroom users as exemplified by a request for more of the terminals. The purchase of equipment meeting the required characteristics at the same or expected lower prices would provide a cost-effective approach to AIS expansion for nongraphic application. New terminals with modems and related communications hardware can be added to the AIS for approximately one-fourth the cost of the similar number of AIS plasma display graphics terminals.

5.2 SOFTWARE

Software was developed and tested during Phase III using the design guides prepared during Phase II. In addition, operating system changes were made to support the new communication system - to handle a revised log-on program - and to the interpreter. The CAMIL language was also modified to recognize new commands and keypresses and to identify the type of terminal connected to the application program. And, applications software editors and data base programs were changed to operate with the format and function key inputs of the new terminals.

5.2.1 System Software Modifications

As described below, the AIS time-shared operating system was modified in the following three areas:

1. A new peripheral processing unit (PPU) program was written to handle the CDC 2551-1 network processing system for communications.

2. The log-on program was modified to provide for the revised terminal format.

3. The interpreter was changed to provide for the new terminal features.

Communications. A new PPU program, ATD, was written to support the channel level input/output requirements of the CDC 2551-1 NPU. The new program receives and transmits all data between the AIS system and

the new terminals. This program also provides the CAMIL and ASCII code conversions. ATD can handle data transmission at rates of up to 9600 bps to each terminal.

This peripheral processor program evolved through several extensively changed versions during the development and checkout phase. It was obvious from the outset that all communications between the CAMIL system and the 2551 NPU would have to be handled on the PPU level since this is the only way to achieve the channel level input/output required by the NPU. The CDC furnished ASCII terminal drivers were found to have an excessive amount of overhead because they were generalized for communication with a large variety of terminals utilizing different protocols. Relatively early, it also became obvious that all communications, both input as well as output, would best be handled from a single PPU program since the status of preceding output attempts is received with the input frames. In order to minimize the added CPU overhead associated with the new terminals, the decision was made to move as much of the CPU overhead as possible--such as CAMIL to ASCII code conversions--into the new PPU program. This program easily handles the four terminals currently operating, and it is expected that up to 64 terminals can be managed with ATD.

Log-on Processor. The log-on processor was modified to utilize the primitive graphics capabilities of the ADDS terminals to provide an AIS logo on the first page. The log-on processor was further modified to operate with only a 24-line display.

Interpreter. Other operating system changes involved some minor modifications to the interpreter to allow the passing of certain functions to terminals not identified as being either AIS interactive/management or ADDS terminals. Also added was a "binary output" primitive. This "binary output" feature was developed to enable the passing of octal data from CAMIL programs to ASCII terminals for the purpose of experimenting with new functions and for features not common to ADDS terminals. This was necessary since the communications system was written to assume that all normal output being sent to the ASCII terminals was CAMIL text and had to be translated to the ASCII codes.

5.2.2 CAMIL Language Modifications

The CAMIL features designed during Phase II were coded and tested during Phase III. CAMIL was modified to provide for the following:

1. Ignoring terminal input when no mapping is provided for a key which has no meaning.

2. Including the type of station connected to the program.

3. Including extra commands to the ADDS terminals so that underlines, inverse video, and other screen attributes can be provided.

4. Providing an interpreter primitive which permits a program to send direct octal commands to an ASCII terminal for direct control.

The new CAMIL commands were successfully used in the modified applications programs which first identify the type of terminals being used and then format the data for either the 32-line AIS plasma panel or the 24-line ADDS Regent 100 terminal. Lines and underlines are also managed differently between the two terminals, with a special underline mode being available on the ADDS.

5.2.3 Application Program Modifications

Applications software changes included the modification of selected existing programs and subroutines so that the low-cost terminals could be used with existing software developed for the plasma terminals. Library routines referenced by the programs were modified and new ones added to accommodate the attributes for each type of terminal. Individual program segments were changed when reformatting was required for the smaller screens. Library subroutines and existing programs were also revised, whenever possible, to provide more efficient operation. The paragraphs below explain the modified subroutine library and provide details regarding modifications of the editors and other applications programs utilized by instructors and learning center managers.

Library of Standard Routines. Various modules of the Library of Standard Routines were modified to define new control variables and implement screen positioning control options which are applied according to the type of terminal in use. Dictionary and global modules were changed to declare new integer, logical, and array variables and to define new procedures in support of the procedure modules (coded routines) of the library. Procedures were changed to accommodate screen-specific attributes with regard to column and line screen positioning, clearing of accept and prompt line areas, setting bounds for writing of the next line, initializing program segment control variables, and handling the logic which controls the general data pages of the editors. New procedures were also added to the library which provide initial values for screen display variables, write headings, control formatting of screen displays, and increase the speed with which data field values are changed in the editors.

Individual Editor Programs. Changes to individual editor programs ranged from minor adjustments (applicable to positioning the accept and prompt lines on the two different screen sizes) to extensive changes in coding which affected the positioning and methods of displaying data fields. Many of the coding changes resulted in streamlined program

statements and structures which are more easily reviewed when troubleshooting or making other modifications. The two categories of changes to particular editor programs are the updating of basic display logic and the restructuring of specific data pages, lists, and arrays.

In general, the segments of an editor program are designed to display either lists of data (vertically displayed) or data in array formats (tables). These segments were modified, where applicable, to provide a more efficient screen display of changed data fields. Only changed data fields are now modified on the screen, whereas previously, other portions of the screen and field description were rewritten.

The task of restructuring and reformatting data field displays was applied to two types of pages: Data Lists and Data Arrays. Both types are controlled by segment modules in the individual editor programs.

The coding to establish appropriate line spacing in the segments which display normal lists of information was changed to accommodate either the plasma panel or ADDS type terminals and their respective vertical screen dimensions.

Several segment control prompting messages were also modified to remove the underscoring from separate characters used for highlighting. Parentheses were substituted for the underscore because the low-cost terminal keyboard is without the special character which allows easy and brief coding of the letter-specific underscore.

Data Array Segment Modifications. Changes to the coding in data array segments incorporated several new internal variables to provide consistent formatting of array displays in all editor programs and to afford easy access to the coding should changes occur to the array dimensions or terminal screen sizes.

5.3 CONCLUSIONS

The feasibility of using low-cost terminals in the AIS was well established. The goals of identifying required characteristics of terminals and demonstrating their validity were also achieved. Users reported high acceptance of the ADDS Regent 100 terminals and the related software and hardware system. Additionally, the results of this experiment definitely reflect the feasibility and desirability of a "mix" of terminal types in an instructional system of this type. A mixed configuration allows matching terminal types to specific requirements in a more cost-effective manner. In the event the system is to be expanded, terminals of this type could be added for approximately one-fourth the cost of the existing plasma terminals.

Reliability of operation can only be proven after several thousand hours of operation. However, operation of the hardware to date indicates good stability. Only two failures occurred with the new terminals and no failures were experienced in the network processor or the modems.

☆U.S. GOVERNMENT PRINTING OFFICE: 1980-671-143/3